

Tuttle Creek Lake 1999 Water Quality Report

1. General.

a. **Project location.** Tuttle Creek Dam is located approximately 6 miles north of Manhattan, Kansas, at river mile 10.0 on the Big Blue River, a tributary of the Kansas River. The project watershed encompasses 9,600 square miles in north-central Kansas and south-central Nebraska.

b. **Authorized project purposes.** Flood control, navigation supplementation for the Missouri River, and water quality are the primary project purposes. Other project purposes are low flow supplementation and recreation.

c. Pertinent data.

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1,000 A.F.)	Surface Area (acres)	Shoreline (miles)
Flood Control	1,136.0	1,903.4	53,600	
Multipurpose	1,075.0	299.5*	14,000	112
Inactive		68.9**		
Total	2,202.9			

Total Drainage Area: 9,600 sq. miles

Average Annual Inflow: 1,860,074 acre-feet

* Based on most recent hydrographic survey

** Contained in multipurpose pool

2. Activities and studies of the year.

Monthly herbicide and nutrient sampling was conducted by lake project personnel, with technical and analytical support from PM-PR-W, April-September 1999 at two inflow stations, three lake stations (two depths), and the outlet. Nutrient samples were shipped to the Chemical and Materials Quality Assurance



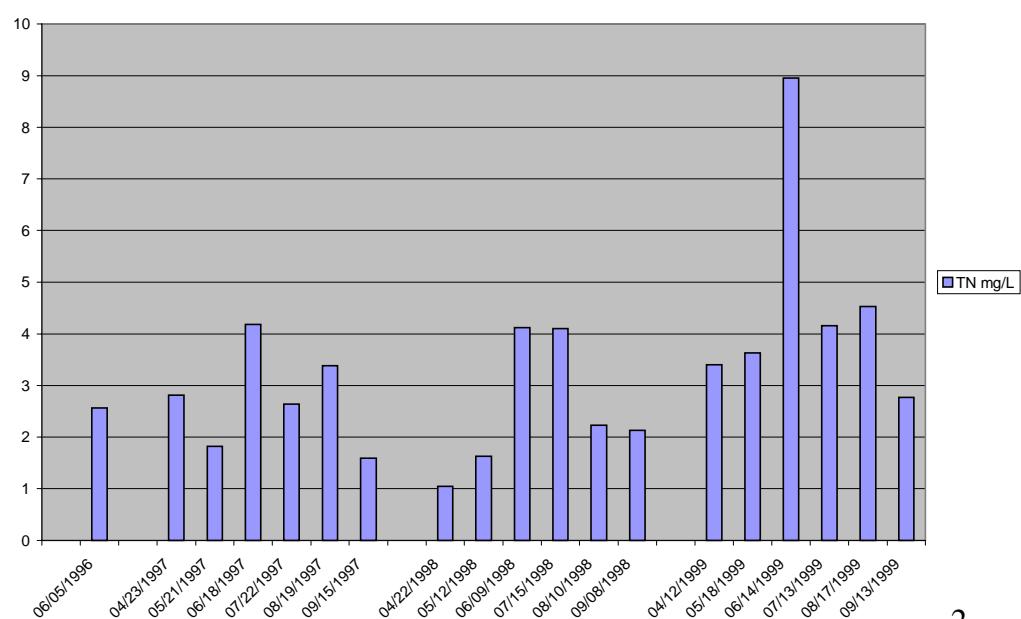
Laboratory (CMQAL) in Omaha for analysis, while the herbicide samples were shipped to the PM-PR-W laboratory for analysis of four of the most commonly occurring herbicides by the ELISA (enzyme linked immunosorbent assay) method. Ten percent of the herbicide samples were shipped to the CMQAL to be analyzed by Gas Chromatography (GC) for quality control purposes. All generated data were entered in excel spreadsheets as an interim to the EPA national water quality data management system, NEW



STORET, which is still in the developmental stage. (Pictures depict Tuttle Creek personnel during a monthly sampling trip.) Table 1 at the end of this report includes all the available nutrient and herbicide data for the past years from 1996-1999.

The OF-TC is to be commended for its continued support of water quality monitoring of Tuttle Creek Lake and its

FIGURE 1: TC-30



tributaries. The OF-TC personnel deserving special recognition include Messrs. Bob Jeffrey, Dale Larson, and Brian McNulty.

FIGURE 2: TC-32

3. Existing Conditions.

a. Inflow.

During the six-month sampling period at the Big Blue River station (TC-30) and the Black Vermillion River station (TC-32), nutrient concentrations were within eutrophic ranges in both streams.

Total nitrogen (i.e., $\text{NH}_3 + \text{NO}_2 + \text{NO}_3 + \text{TKN}$) mean concentrations were 4.57 mg/L and 3.84 mg/L at TC-30 and TC-32, respectively. Total nitrogen concentrations for the period of record have generally exceeded the EPA criterion for the protection

of aquatic ecosystems from excessive eutrophication ($<1 \text{ mg/L}$) and have demonstrated the elevated, long-term, nutrient loading to both streams. Figures 1 and 2 show the trend for total nitrogen concentrations over the past three years.

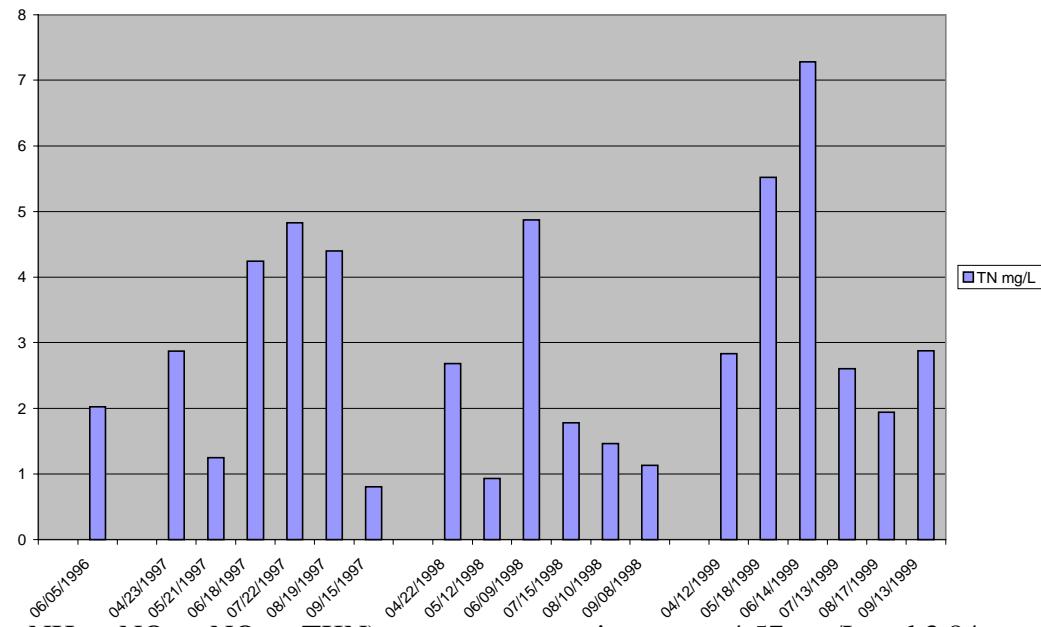
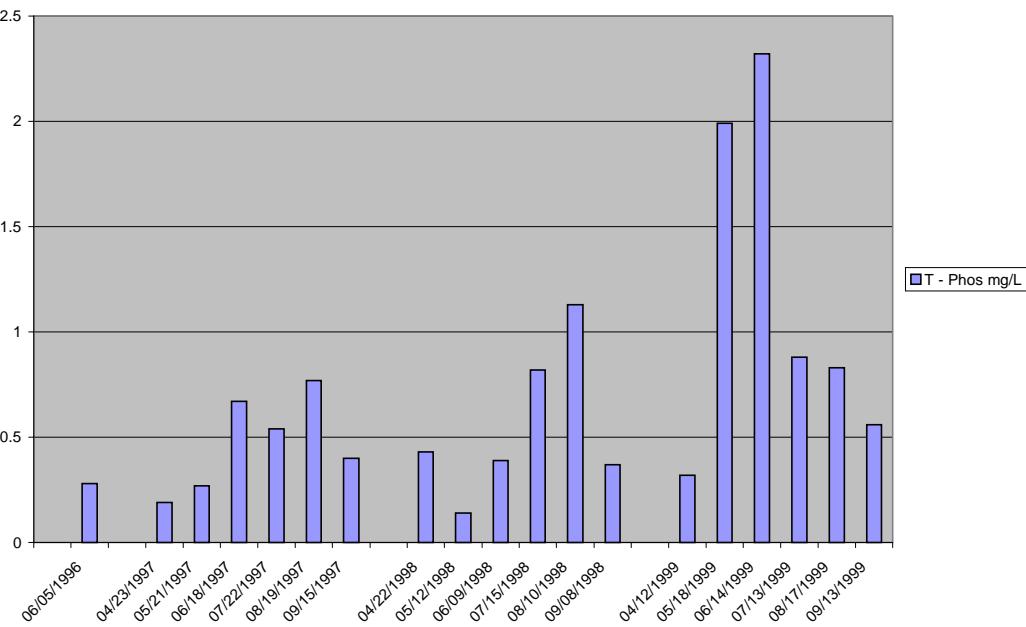


FIGURE 3: TC-30



Spikes typically occur during high inflows such as May and June 1999. The total phosphorus mean concentrations of 1.15 mg/L and 0.62 mg/L at TC-30 and TC-32, respectively, were also higher than the EPA suggested stream criterion of 0.1 mg/L for the protection of aquatic

ecosystems. Both streams have been characterized by hypereutrophic phosphorus levels over the period of record, especially during storm run-off events. Figures 3 and 4 show this trend for the past three years.

Of the four herbicides (atrazine, alachlor, metolachlor, and cyanazine) tested, all four were detected at both TC-30 and TC-32, with the highest concentrations being detected in June. The monthly concentrations of atrazine ranged from 20.20 ug/L to 0.76 ug/L, mean of 7.42, at TC-

30 and from 25.70 ug/L to 0.52 ug/L, mean of 6.91, at TC-32.

Atrazine

concentrations at both TC-30 and TC-32 exceeded the EPA maximum contaminant level (MCL) for drinking water supplies (3 ug/L) in

May and June. The concentrations of atrazine were much lower during other months of the year representative of low flow periods. Figures 5 and 6 show this typical pattern of high concentrations during high flow with lower concentrations during other months. Mean and

FIGURE 4: TC-32

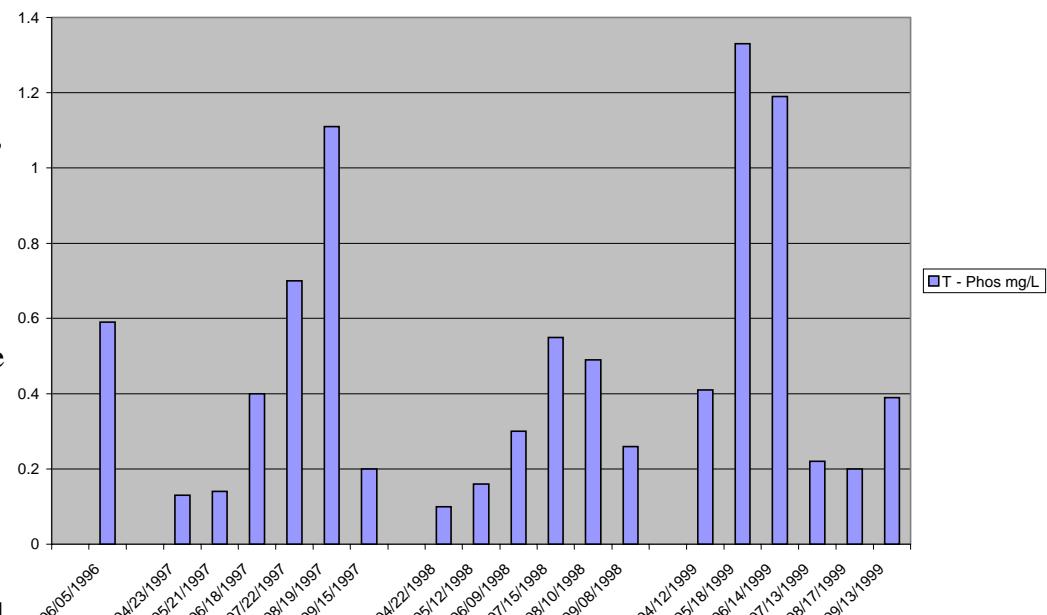
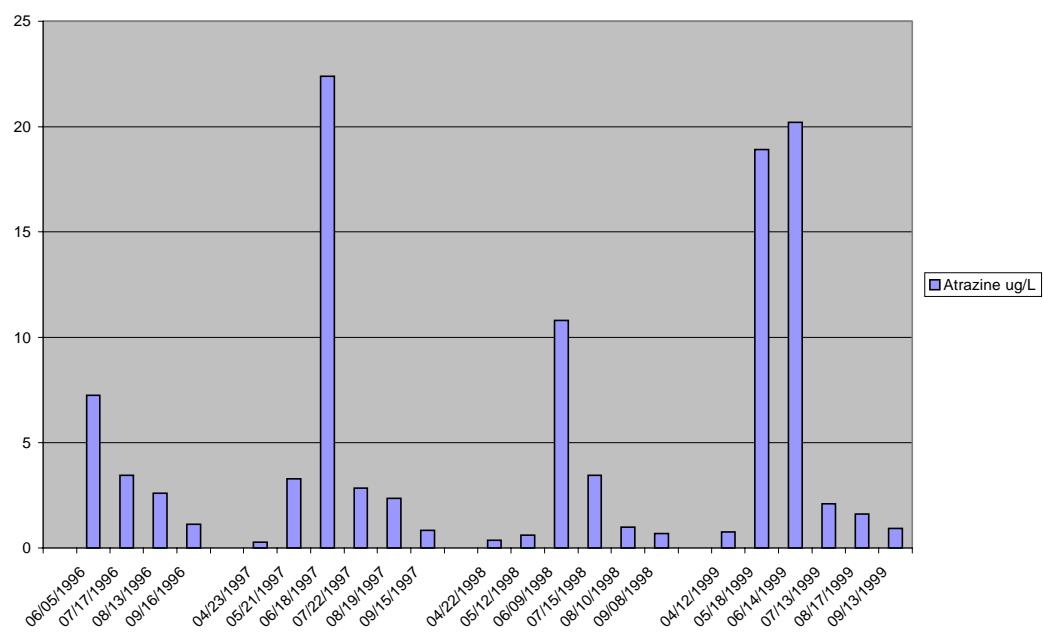


FIGURE 5: TC-30



maximum alachlor concentrations at both stations were (3.01 ug/L and 8.00 ug/L, respectively, at TC-30 and 1.91 ug/L and 6.60 ug/L, respectively, at TC-32. Thirty-three percent of the samples at each station were above the EPA MCL of 2 ug/L. To date the EPA has not set a standard for metolachlor, but concentrations at

TC-30 and TC-32 seemed high in May and June (4.68 ug/L and 9.00 ug/L, TC-30, and TC-32, 3.94 ug/L and 8.70 ug/L). Cyanazine concentrations were all below the EPA maximum contaminant level goal (MCLG) of 1 ug/L. All of these values seem to reflect the trend of higher concentrations in the early months of the growing season with decreasing values following. Over the period of record, a dozen pesticides have been detected in the streams with atrazine and alachlor continually exceeding the EPA criteria for the protection of aquatic life and drinking water supplies.

b. Lake. Stations TC-3, TC-8, and TC-11

were sampled during the six-month sampling period from mid April-September 1999. As can be seen in figures 7, 8, and 9, nutrient concentrations were typical of the impoundment over the period of record. These three graphs show the relationship between surface and bottom concentrations

FIGURE 6: TC-32

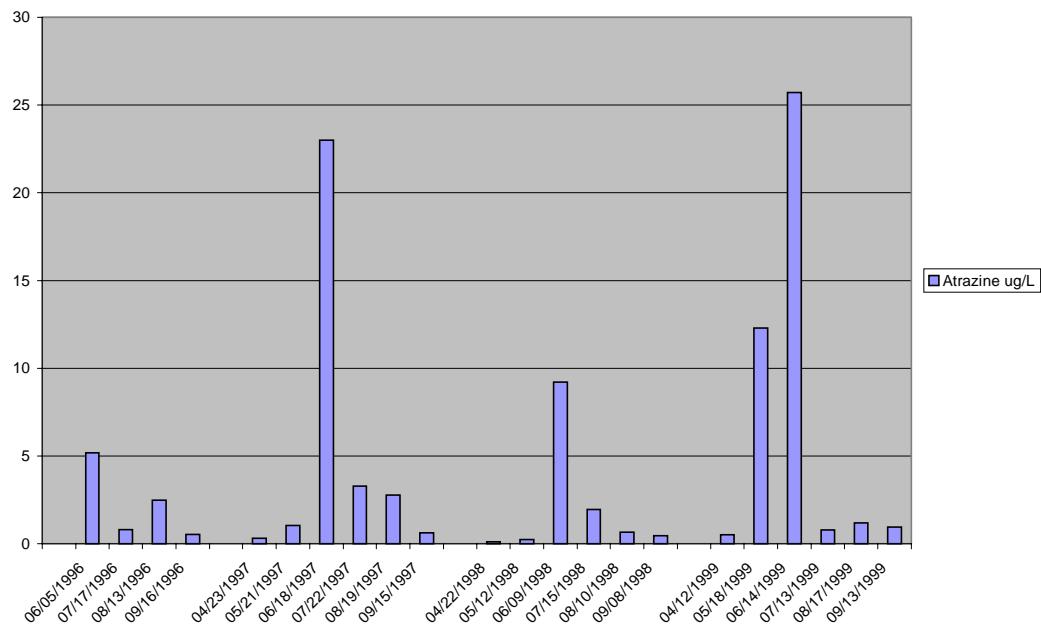
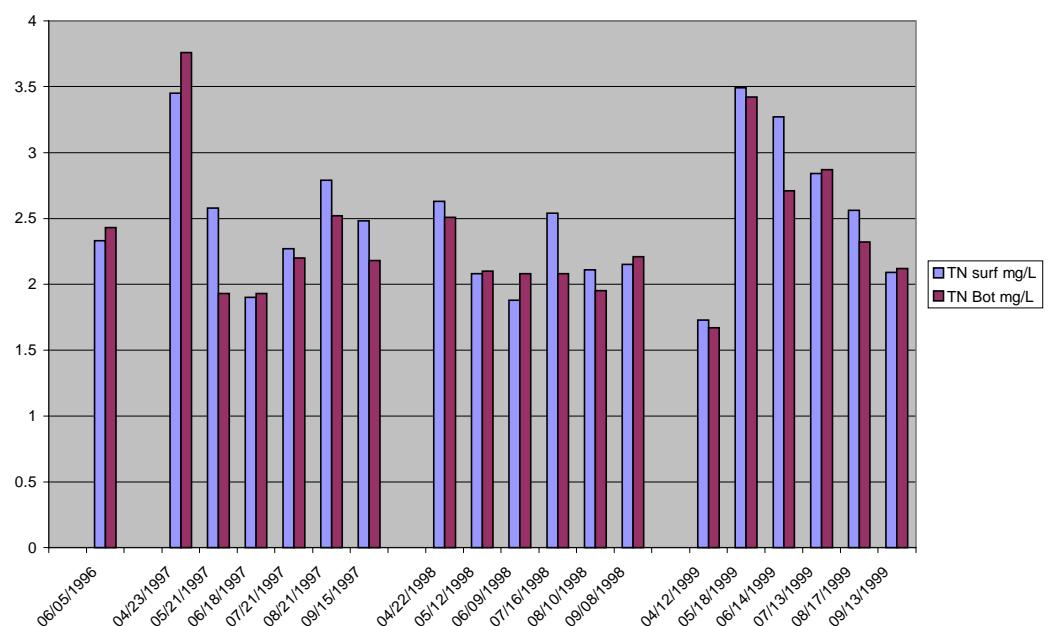


FIGURE 7: TC-3



for the past three years. Concentrations within the water column and throughout the lake appear to be fairly uniform. The 1999 mean and maximum total nitrogen concentrations in the surface waters were 2.66 mg/L and 3.49 mg/L, respectively, at TC-3 (downlake), 2.72 mg/L and 3.31 mg/L,

respectively, at TC-8 (midlake), and 3.05 mg/L and 3.58 mg/L, respectively, at TC-11 (uplake). These concentrations remained fairly constant from TC-11 to TC-3. Values in the bottom waters were consistent with those of the surface waters

FIGURE 8: TC-8

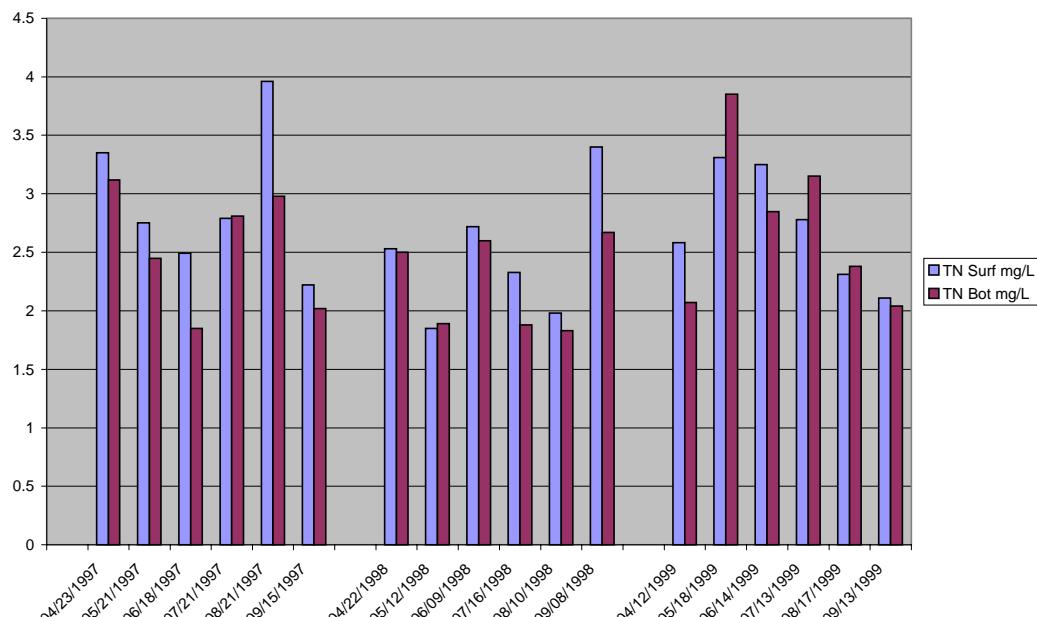
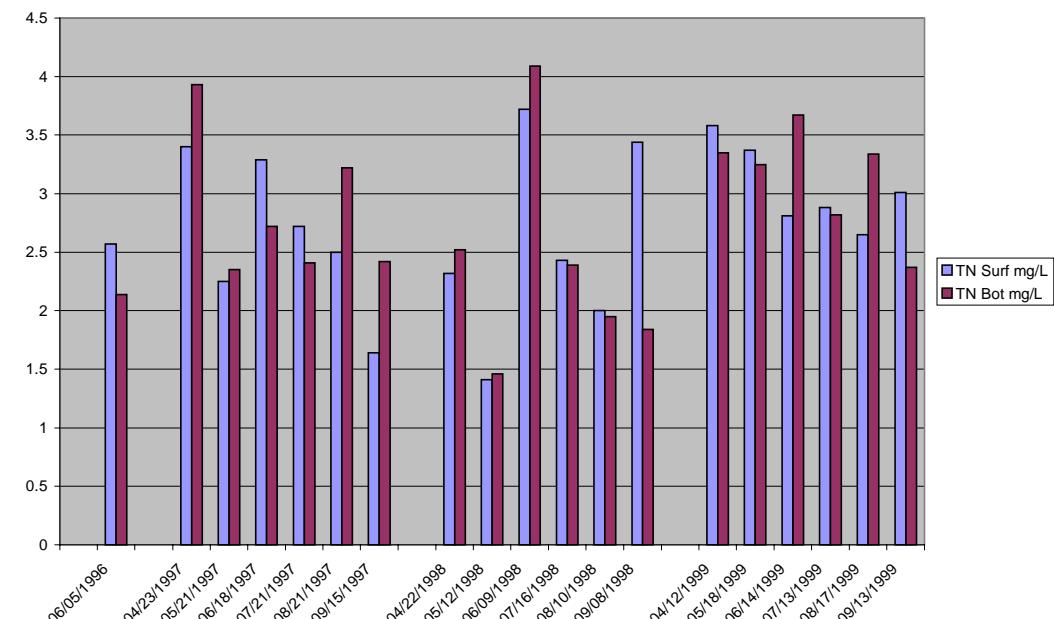


FIGURE 9: TC-11



with mean and maximum concentrations of 2.52 mg/L and 3.42 mg/L, respectively, at TC-3, 2.72 mg/L and 3.85 mg/L, respectively, at TC-8, and 3.13 mg/L and 3.67 mg/L, respectively, at TC-11. Total phosphorus concentrations contributed to the eutrophic nature of the lake with mean and maximum concentrations in the surface waters of 0.28 mg/L and 0.49 mg/L, respectively, at TC-3, 0.30 mg/L and 0.52 mg/L, respectively, at TC-8, and 0.34 mg/L and 0.53 mg/L, respectively, at TC-11. Mean total phosphorus concentrations in the bottom waters were fairly consistent with the concentrations in the surface waters. Figures 10, 11, and 12 show concentrations at the surface and bottom depths throughout the lake from

1996-1999. Total phosphorus concentrations tend to follow the same pattern as the total nitrogen concentrations, fairly uniform throughout the lake. These nutrient levels continue to be within highly eutrophic ranges.

FIGURE 10: TC-3

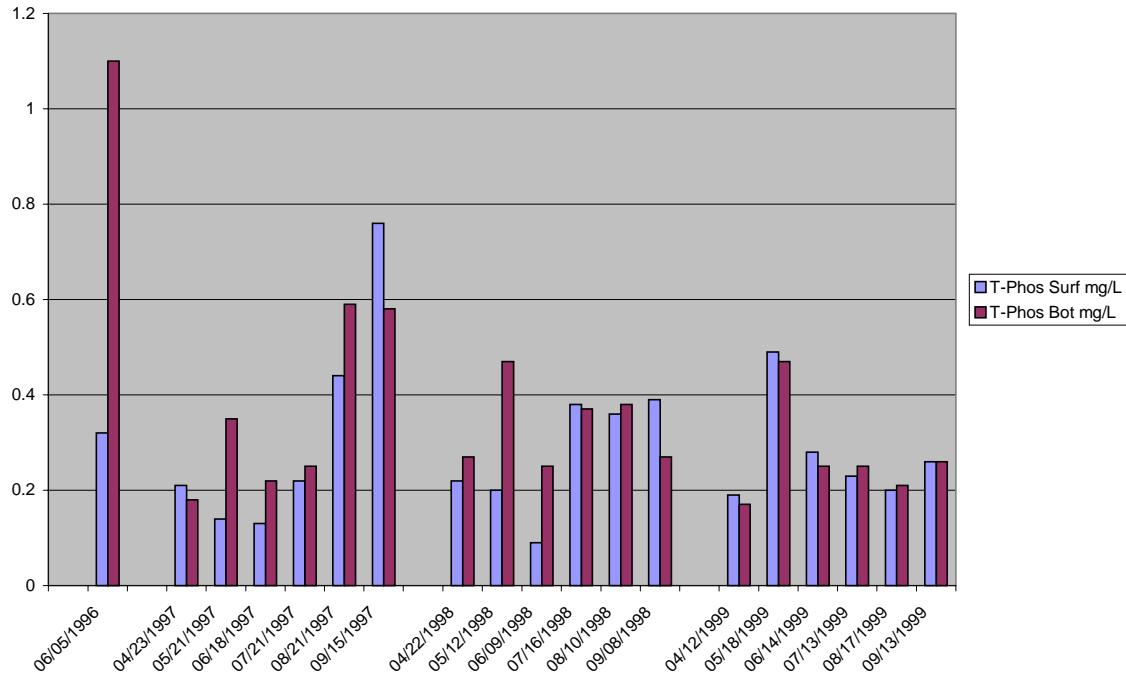


FIGURE 11: TC-8

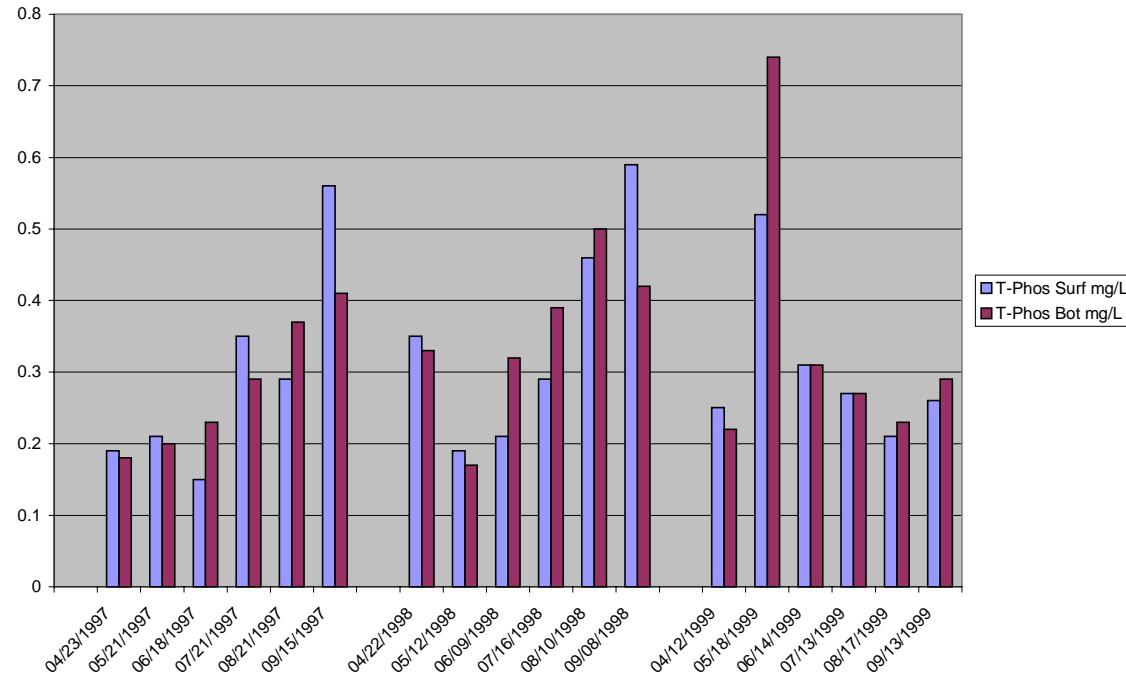
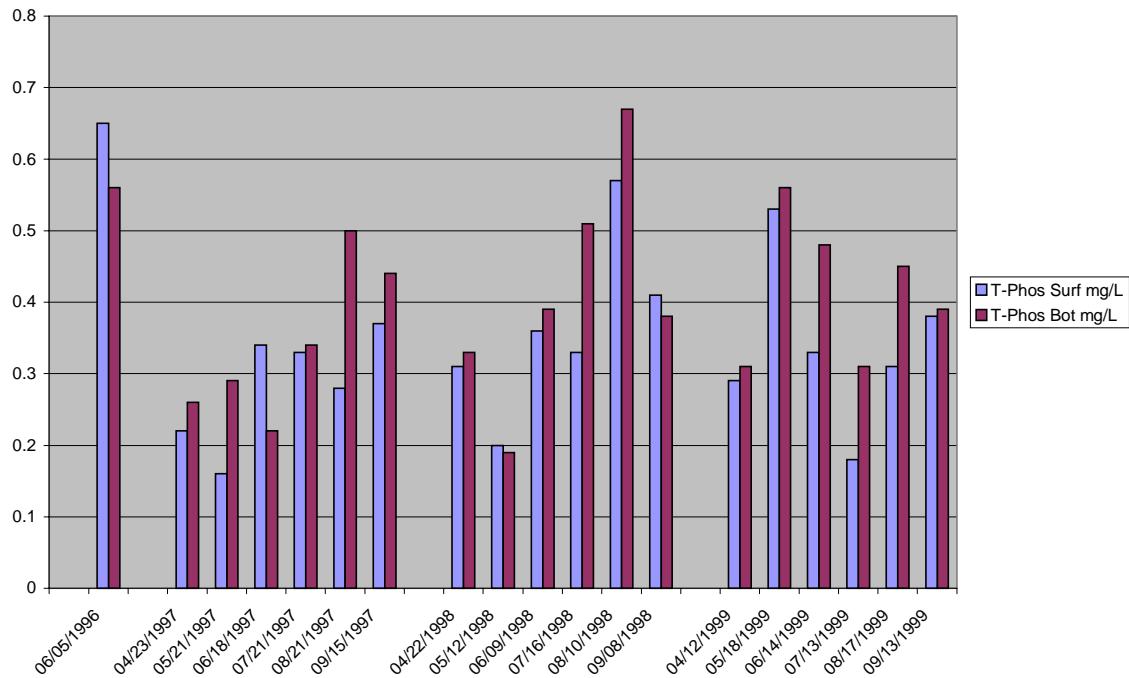


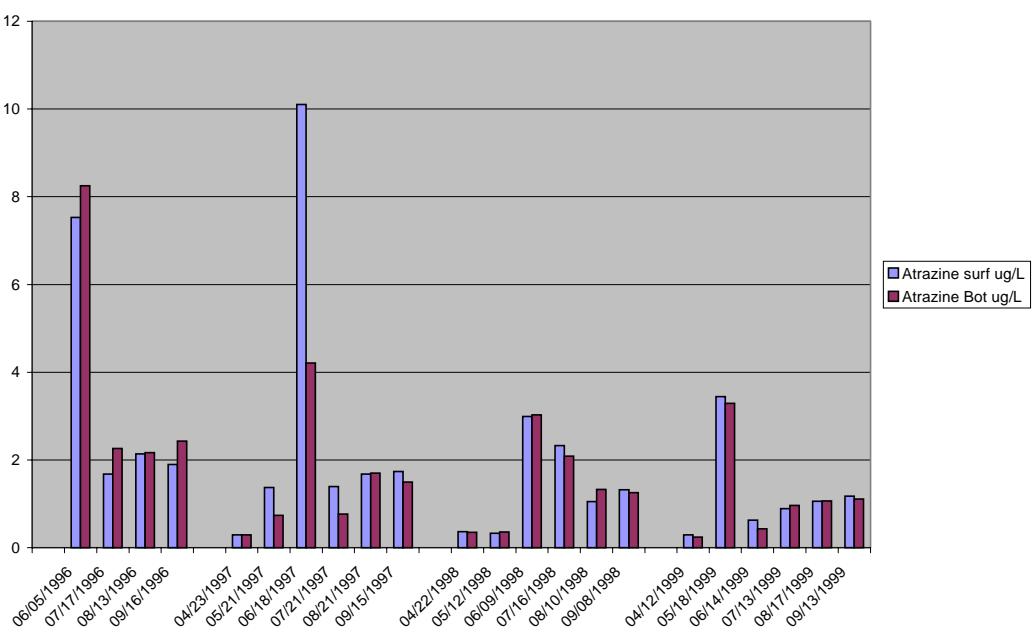
FIGURE 12: TC-11



In the six-month sampling period for herbicides, TC-3 (downlake), TC-8 (midlake), and TC-11 (uplake) were sampled. All four of the herbicides tested (atrazine, alachlor, metolachlor, and cyanazine) were detected both in surface and bottom waters. Atrazine was detected in 100% of the samples with the highest concentrations occurring in May. Concentrations of atrazine exceeding the MCL of 3 ug/L occurred in 19% of the samples. The mean and maximum atrazine concentrations in the surface waters of the lake

FIGURE 13: TC-3

were as follows: 1.25 ug/L and 3.44 ug/L (TC-3); 1.44 ug/L and 4.03 ug/L (TC-8); and 2.86 ug/L and 10.5 ug/L (TC-11), respectively. Bottom mean and maximum atrazine concentrations for the above areas were 1.19 ug/L and 3.29



ug/L; 3.79 ug/L and 1.42 ug/L; and 3.54 ug/L and 12.5 ug/L, respectively. Figures 13, 14, and 15 show the trend for atrazine for the years 1996–1999. As can be seen from these graphs high concentrations occur throughout the lake in early spring during the high run-off periods and then level off.

For the most part,

concentrations

are uniform throughout the water column.

Alachlor

concentrations exceeded the MCL of 2

ug/L in 50% of the 1999 samples. The

mean and

maximum alachlor concentrations in the surface waters were as follows, 2.83 ug/L and 3.44 ug/L (TC-3); 2.51 ug/L and 4.03 ug/L (TC-8); and 2.17 ug/L and 4.60 ug/L (TC-11), respectively.

Bottom mean and maximum alachlor

concentrations for

the above areas were

2.52 ug/L and 4.67

ug/L; 2.48 ug/L and

5.40 ug/L; and 2.18 ug/L

and 4.19 ug/L,

respectively.

Cyanazine

concentrations

did not exceed the

MCLG of 1

ug/L in any of the 1999 samples. No standard has been set for metolachlor, however, 33% of the

1998 samples exceeded 3 ug/L. The mean and maximum metolachlor concentrations in the

surface waters were 3.59 ug/L and 10.00 ug/L (TC-3); 2.98 ug/L and 4.92 ug/L (TC-8); and

FIGURE 14: TC-8

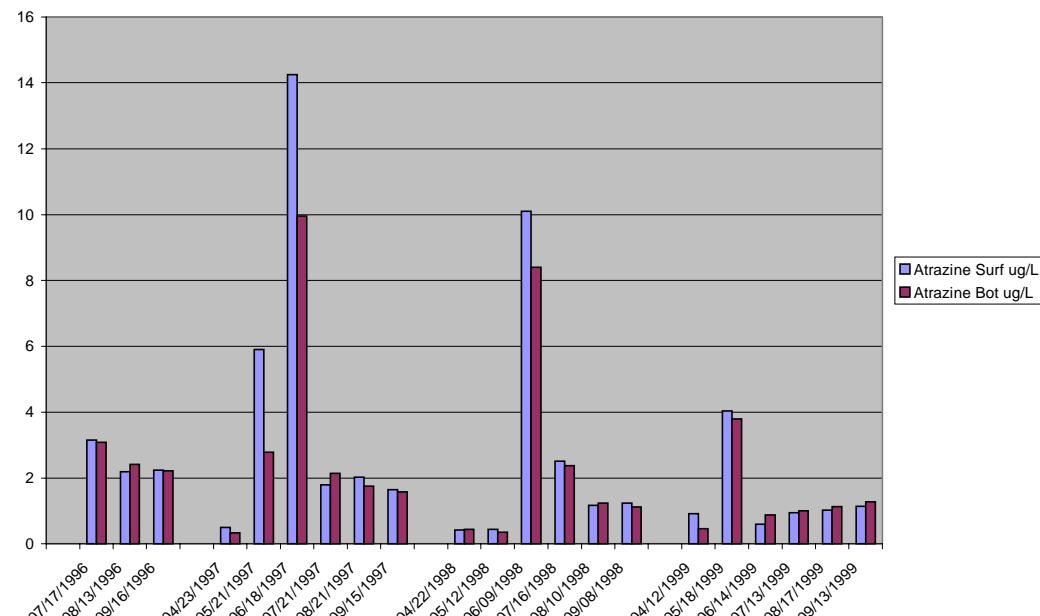
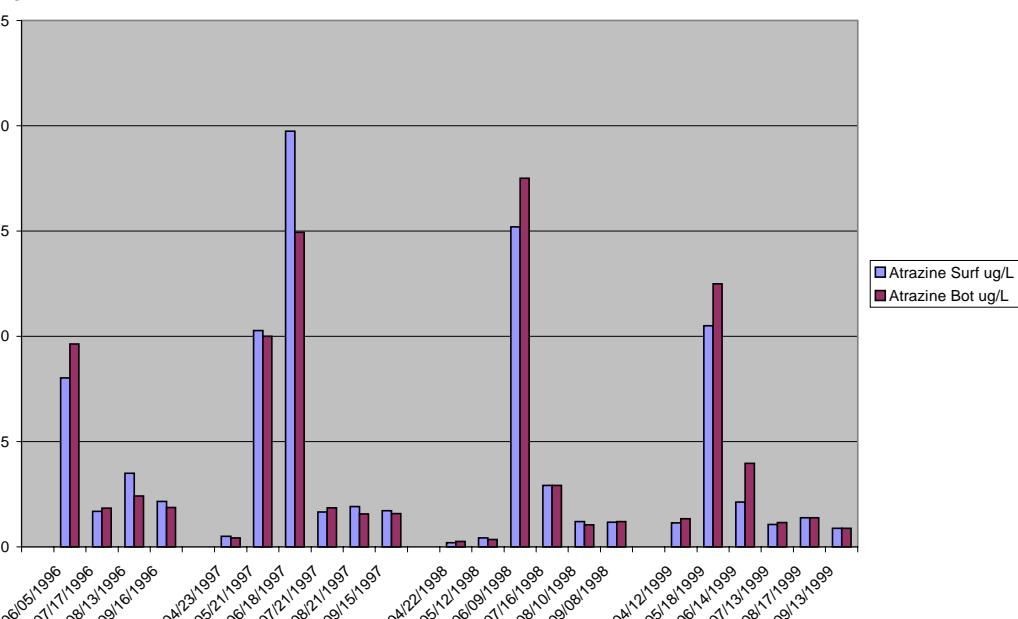


FIGURE 15: TC-11

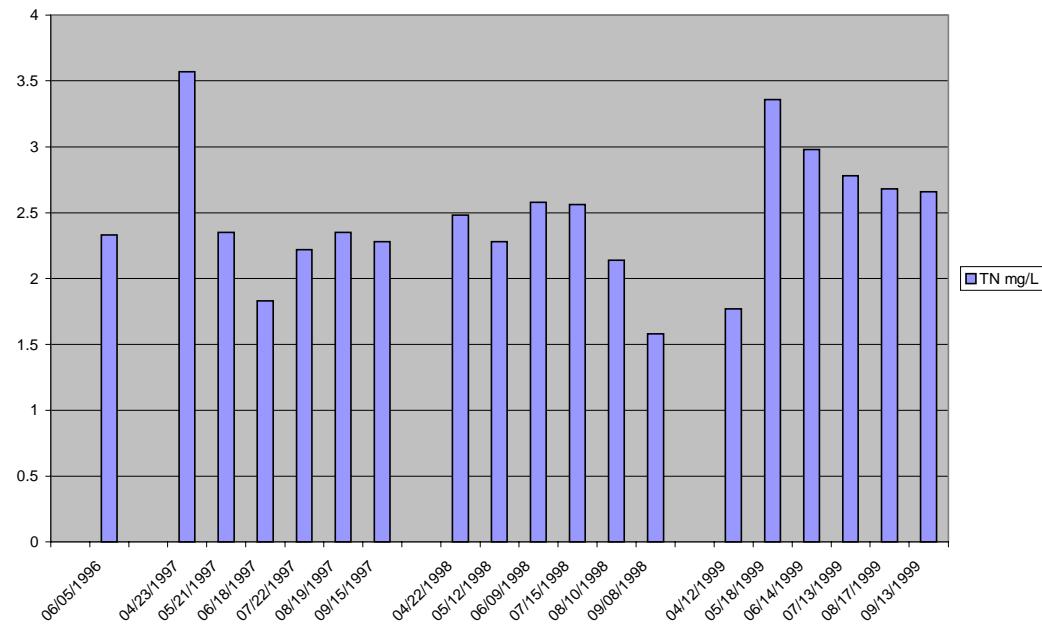


2.58 ug/L and 4.68 ug/L, respectively. Bottom mean and maximum concentrations for the above areas were 2.72 ug/L and 4.56 ug/L; 3.33 ug/L and 4.41 ug/L; and 2.59 ug/L and 4.36 ug/L, respectively. It should be noted that concentrations of these pesticides were fairly uniform throughout the water column.

c. Outflow. The water quality of the downstream reach (station TC-27)

maintained most of the qualities of the bottom withdrawal waters. Total nitrogen and total phosphorus mean concentrations continued in eutrophic ranges at 2.71 mg/L and 0.28 mg/L, respectively.

FIGURE 16: TC-27



Again, as shown in figures 16 and 17, concentrations are higher during

FIGURE 17: TC-27

the high run-off periods. Also, concentrations of atrazine, alachlor, metolachlor, and cyanazine were very similar to those of bottom downlake waters in 1999. The mean and maximum atrazine concentrations were 1.22 ug/L and 3.56 ug/L, respectively, with the maximum occurring in May indicating the

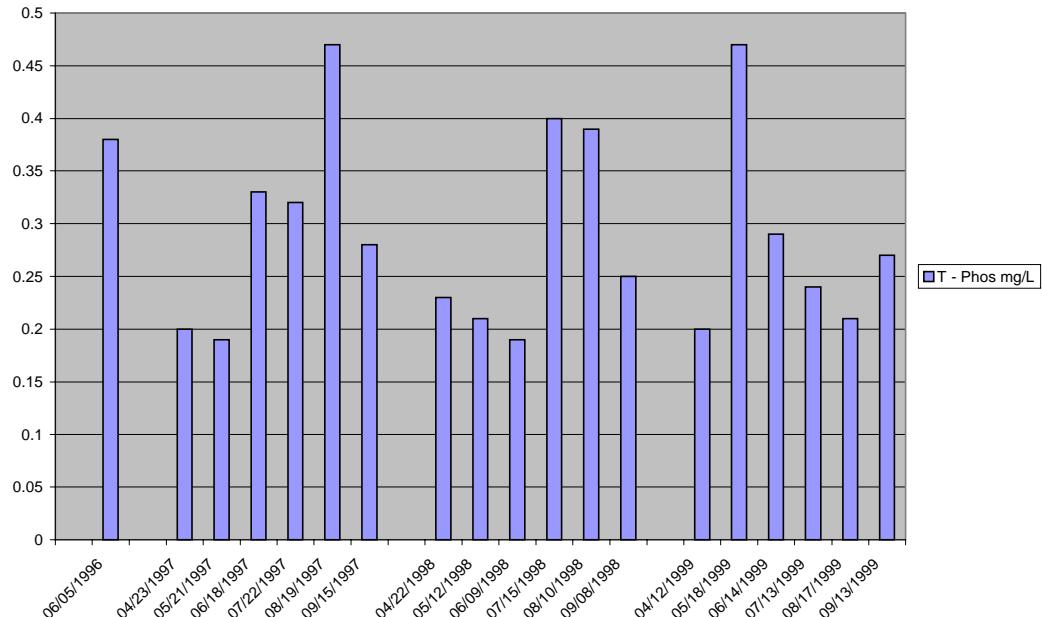
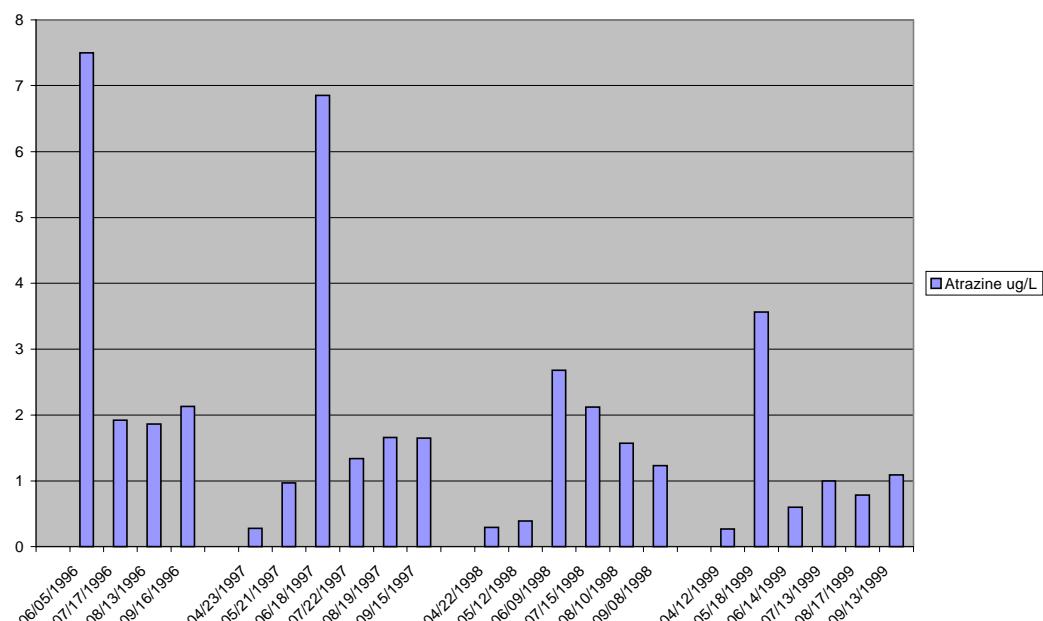


FIGURE 18: TC-27

highest concentrations of

atrazine appeared to be flowing in, through, and out of the lake with only short residence times. One of the six samples collected exceeded the MCL of 3 ug/L for atrazine.

Figure 18 shows the trend for the years



1996-1999. As can be seen from this graph, there was a decrease in atrazine concentrations in the outlet during most of the 1999 sampling period. The mean and maximum alachlor concentrations were 2.85 ug/L and 6.70 ug/L, respectively. Fifty percent of the 1999 samples exceeded the MCL of 2 ug/L for alachlor. The mean and maximum cyanazine concentrations were 0.15 ug/L and .31 ug/L, respectively. None of the six samples collected exceeded the MCLG of 1 ug/L for cyanazine. The mean and maximum metolachlor concentrations were 3.48 ug/L and 9.40 ug/L, respectively. There is no set standard for metolachlor.

4. Future conditions.

The water quality of Tuttle Creek Lake is only moderately good. The extremely high suspended solids load entering the reservoir during storm events has caused excessive sedimentation in the upper third of the original pool sharply reducing its size. The associated turbidity adversely affects the sport fishery and, therefore, the recreation benefits of the project. Pesticide surveys continue to show heavy herbicide loading is associated with the storm run-off. The reservoir is acting as a pesticide sink with the result that its discharges contain pesticide concentrations throughout the year which are significantly lower than those of the inflows during storm events but elevated above the levels present in the tributaries during non-storm event periods. The continually elevated levels pose a risk to water supply benefits for the Kansas River. Atrazine concentrations for the impoundment during the period of record show a continued exceedence of the EPA criterion of 1 ug/L for the protection of aquatic life. The concentrations in many periods exceed the EPA MCL of 3 ug/L, the maximum permissible level of a contaminant in public drinking water supplies. If soil conservation practices are not substantially improved and pesticide usage altered, the conditions will only worsen, which will

sharply reduce the project's benefits of flood control, water quality, and recreation.

5. Recommendations.

At the beginning of FY99, planning meetings were held with other state and Federal agencies to develop a Total Maximum Daily Load (TMDL) for atrazine. A watershed management plan is to be developed and implemented, which will improve the TMDL for atrazine and other water quality parameters such as nutrients. No additional monitoring has been requested for 2000. Therefore, the water quality surveillance program for Tuttle Creek Lake should continue with routine monthly pesticide sampling to be conducted by Project personnel with logistical and analytical support from PM-PR-W.

TABLE 1: TUTTLE CREEK LAKE DATA 1996-1999

Station	Depth M	Date mm/dd/yy	Time hh/mm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	Ammonia mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L
TC - 30	0.1	06/05/1996	1430	7.25	4.64	5.35	0.92	0.06	1.6	0.9	2.56	0.28	0.6
	0.1	07/17/1996	1315	3.45	1.04	2.21	0.16						
	0.1	08/13/1996	1300	2.61	1.04	1.05	0.16						
	0.1	09/16/1996	1230	1.14	0.54	0.41	0.11						
Average				3.61	1.82	2.26	0.34	0.06	1.60	0.90	2.56	0.28	0.60
TC - 30	0.1	04/23/1997	1330	0.28	0.28	0.23	<0.04	0.37	1.04	1.4	2.81	0.19	0.17
	0.1	05/21/1997	1410	3.29	1.14	2.39	0.28	0.02		1.8	1.82	0.27	0.03
	0.1	06/18/1997	1330	22.4	6.94	4.91	0.88	0.07	2.01	2.1	4.18	0.67	0.39
	0.1	07/22/1997	0930	2.84	1.71	2.14	0.13	0.03	1.91	0.7	2.64	0.54	0.39
	0.1	08/19/1997	1410	2.35	1.46	1.16	0.13	<0.02	1.78	1.6	3.38	0.77	0.4
	0.1	09/15/1997	1405	0.84	0.34	0.21	0.04	0.02	0.17	1.4	1.59	0.4	0.12
	Average			5.33	1.98	1.84	0.29	0.10	1.38	1.50	2.74	0.47	0.25
TC - 30	0.1	04/22/1998	1340	0.37	0.19	0.05	0.05	<0.02	0.85	0.2	1.05	0.43	0.34
	0.1	05/12/1998	1320	0.62	0.2	0.28	0.05	0.02	0.01	1.6	1.63	0.14	0.01
	0.1	06/09/1998	1330	10.8	2.12	4.17	0.34	<0.02	2.22	1.9	4.12	0.39	0.34
	0.1	07/15/1998	1245	3.45	2.65	1.61	1.94	0.07	2.33	1.7	4.1	0.82	0.34
	0.1	08/10/1998	1315	0.99	0.72	0.85	0.1	0.03	1.4	0.8	2.23	1.13	0.47
	0.1	09/08/1998	1305	0.69	0.33	0.22	0.06	0.12	0.21	1.8	2.13	0.37	0.27
	Average			2.82	1.04	1.20	0.42	0.06	1.17	1.33	2.54	0.55	0.30
TC - 30	0.1	04/12/1999	1330	0.76	0.19	0.41	0.06	U	1.7	1.7	3.4	0.32	0.26
	0.1	05/18/1999	1255	18.9	8	4.68	0.64	0.02	2.33	1.28	3.63	1.99	0.21
	0.1	06/14/1999	1250	20.2	6.9	9	0.42	0.22	2.05	6.68	8.95	2.32	0.18
	0.1	07/13/1999	1235	2.11	1.98	2.01	0.58	0.18	1.78	2.2	4.16	0.88	0.34
	0.1	08/17/1999	1240	1.62	0.74	0.98	0.08	0.04	2.29	2.2	4.53	0.83	0.49
	0.1	09/13/1999	1330	0.93	0.25	0.17	<0.04	U	1.28	1.49	2.77	0.56	0.32
	Average			7.42	3.01	2.88	0.36	0.12	1.91	2.59	4.57	1.15	0.30
TC - 32	0.1	06/05/1996	1330	5.18	2.27	2.89	0.26	0.07	1.35	0.6	2.02	0.59	0.59
	0.1	07/17/1996	1340	0.81	0.35	0.51	<0.04						
	0.1	08/13/1996	1330	2.5	1.2	1.1	0.11						
	0.1	09/16/1996	1300	0.53	0.28	0.1	<0.04						
Average				2.26	1.03	1.15	0.19	0.07	1.35	0.60	2.02	0.59	0.59
TC - 32	0.1	04/23/1997	1415	0.32	0.37	0.25	0.05	0.67	1.1	1.1	2.87	0.13	0.11
	0.1	05/21/1997	1440	1.04	0.4	0.6	0.12	0.03	0.32	0.9	1.25	0.14	0.07
	0.1	06/18/1997	1415	23	7.84	4.71	0.28	0.09	2.15	2	4.24	0.4	0.23
	0.1	07/22/1997	1000	3.28	1.28	1.14	0.11	0.35	0.88	3.6	4.83	0.7	0.15
	0.1	08/19/1997	1440	2.77	3.21	0.95	0.14	0.14	1.06	3.2	4.4	1.11	0.24
	0.1	09/15/1997	1440	0.63	0.27	0.11	<0.04	0.03	0.07	0.7	0.8	0.2	0.1
	Average			5.17	2.23	1.29	0.14	0.22	0.93	1.92	3.07	0.45	0.15

Station	Depth M	Date mm/dd/yy	Time hh/mm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	Ammonia mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L
TC - 32	0.1	04/22/1998	1425	0.12	0.11	<0.05	<0.04	0.04	2.04	0.6	2.68	0.1	0.1
	0.1	05/12/1998	1400	0.25	0.14	0.12	<0.04	0.02	0.31	0.6	0.93	0.16	0.04
	0.1	06/09/1998	1400	9.2	1.73	12.9	0.2	0.41	2.26	2.2	4.87	0.3	0.14
	0.1	07/15/1998	1330	1.96	1.4	0.93	1.11	0.14	0.94	0.7	1.78	0.55	0.17
	0.1	08/10/1998	1400	0.68	1.4	0.23	0.08	0.09	0.77	0.6	1.46	0.49	0.18
	0.1	09/08/1998	1340	0.46	0.33	0.11	0.04	0.13	0.5	0.5	1.13	0.26	0.16
Average				2.11	0.85	2.86	0.36	0.14	1.14	0.87	2.14	0.31	0.13
TC - 32	0.1	04/12/1999	1400	0.52	0.2	0.21	<0.04	0.05	1.96	0.82	2.83	0.41	0.18
	0.1	05/18/1999	1330	12.3	3.2	3.94	0.21	0.18	2.69	2.65	5.52	1.33	0.1
	0.1	06/14/1999	1325	25.7	6.6	8.7	0.33	0.12	2.92	4.24	7.28	1.19	0.11
	0.1	07/13/1999	1310	0.8	0.68	0.7	0.22	0.09	2.23	0.28	2.6	0.22	0.13
	0.1	08/17/1999	1310	1.19	0.51	0.43	0.09	U	1.45	0.49	1.94	0.2	0.16
	0.1	09/13/1999	1400	0.96	0.24	0.23	<0.04	U	1.44	1.44	2.88	0.39	0.21
Average				6.91	1.91	2.37	0.21	0.11	2.12	1.65	3.84	0.62	0.15
TC - 27	0.1	06/05/1996	1200	7.5	5.69	5.79	1.01	0.02	1.81	0.5	2.33	0.38	0.13
	0.1	07/17/1996	1430	1.92	3.58	3.82	0.1						
	0.1	08/13/1996	1430	1.86	3.36	3.11	0.16						
	0.1	09/16/1996	1400	2.13	2.12	3.01	0.17						
Average				3.35	3.69	3.93	0.36	0.02	1.81	0.50	2.33	0.38	0.13
TC - 27	0.1	04/23/1997	1520	0.28	0.34	0.41	<0.04	0.93	1.44	1.2	3.57	0.2	0.16
	0.1	05/21/1997	1540	0.97	0.51	0.83	0.14	0.11	1.24	1	2.35	0.19	0.13
	0.1	06/18/1997	1505	6.85	2.73	2.43	0.35	0.07	1.06	0.7	1.83	0.33	0.12
	0.1	07/22/1997	1100	1.34	4.82	3.46	0.07	0.02	1.7	0.5	2.22	0.32	0.17
	0.1	08/19/1997	1550	1.66	2.87	3.8	0.12	<0.02	1.55	0.8	2.35	0.47	0.18
	0.1	09/15/1997	1550	1.65	2.25	2.08	0.11	<0.02	1.28	1	2.28	0.28	0.18
Average				2.13	2.25	2.17	0.16	0.28	1.38	0.87	2.43	0.30	0.16
TC - 27	0.1	04/22/1998	1525	0.29	0.32	0.15	<0.04	0.33	1.45	0.7	2.48	0.23	0.12
	0.1	05/12/1998	1515	0.39	0.32	0.3	0.04	0.05	1.53	0.7	2.28	0.21	0.17
	0.1	06/09/1998	1525	2.68	1.14	1.83	0.32	0.07	1.51	1	2.58	0.19	0.11
	0.1	07/15/1998	0845	2.12	4.97	7	3.6	0.09	1.67	0.8	2.56	0.4	0.17
	0.1	08/10/1998	1500	1.57	3.62	3.43	0.11	0.06	1.68	0.4	2.14	0.39	0.23
	0.1	09/08/1998	1450	1.23	1.53	2.14	0.09	0.02	0.86	0.7	1.58	0.25	0.15
Average				1.38	1.98	2.48	0.83	0.10	1.45	0.72	2.27	0.28	0.16
TC - 27	0.1	04/12/1999	1510	0.27	0.17	0.12	<0.04	0.15	1.15	0.47	1.77	0.2	0.17
	0.1	05/18/1999	1440	3.56	0.62	1.82	0.18	0.32	2.15	0.89	3.36	0.47	0.15
	0.1	06/14/1999	1440	0.6	6.7	9.4	<0.04	U	2.08	0.9	2.98	0.29	0.2
	0.1	07/13/1999	1425	1	4.49	4.49	0.31	0.08	2.21	0.49	2.78	0.24	0.17
	0.1	08/17/1999	1415	0.78	3.17	2.6	0.06	0.09	1.82	0.77	2.68	0.21	0.2
	0.1	09/13/1999	1510	1.09	1.93	2.47	0.05	0.28	1.65	0.73	2.66	0.27	0.19
Average				1.22	2.85	3.48	0.15	0.18	1.84	0.71	2.71	0.28	0.18

Station	Depth M	Date mm/dd/yy	Time hh/mm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	Ammonia mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L
TC - 3	0.1	06/05/1996	0800	7.53	4.87	5.56	1.17	<0.02	1.93	0.4	2.33	0.32	0.17
	0.1	07/17/1996	1100	1.68	4.18	4.1	0.09						
	0.1	08/13/1996	1045	2.14	3.12	3.69	0.16						
	0.1	09/16/1996	1030	1.9	<0.1	0.5	<0.1						
Average				3.31	4.06	3.46	0.47		1.93	0.40	2.33	0.32	0.17
TC - 3	0.1	04/23/1997	1110	0.3	0.38	0.42	<0.04	0.96	1.49	1	3.45	0.21	0.17
	0.1	05/21/1997	1225	1.37	0.6	0.99	0.16	0.15	1.33	1.1	2.58	0.14	0.11
	0.1	06/18/1997	1120	10.1	3.28	3.94	<0.1	<0.02	1	0.9	1.9	0.13	0.1
	0.1	07/21/1997	1540	1.39	2.2	4.48	0.06	<0.02	1.87	0.4	2.27	0.22	0.18
	0.1	08/21/1997	1010	1.68	3.75	3.41	0.17	0.29	1.5	1	2.79	0.44	0.17
	0.1	09/15/1997	1230	1.74	2.34	2.9	0.1	0.04	1.44	1	2.48	0.76	0.45
Average				2.76	2.09	2.69	0.12	0.36	1.44	0.90	2.58	0.32	0.20
TC - 3	0.1	04/22/1998	1045	0.37	0.32	0.17	<0.04	0.37	1.46	0.8	2.63	0.22	0.2
	0.1	05/12/1998	1050	0.33	0.31	0.25	<0.04	0.02	1.36	0.7	2.08	0.2	0.15
	0.1	06/09/1998	1010	2.99	1.14	1.51	0.32	<0.02	1.48	0.4	1.88	0.09	0.05
	0.1	07/16/1998	1020	2.33	4.51	4.6	3.2	0.11	1.73	0.7	2.54	0.38	0.2
	0.1	08/10/1998	1030	1.05	3.43	4.06	0.09	0.02	1.59	0.5	2.11	0.36	0.21
	0.1	09/08/1998	1020	1.32	<0.05	2.34	0.13	0.02	1.83	0.3	2.15	0.39	0.22
Average				1.40	1.94	2.16	0.94	0.11	1.58	0.57	2.23	0.27	0.17
TC - 3	0.1	04/12/1999	1120	0.3	0.19	0.13	<0.04	0.17	1.18	0.38	1.73	0.19	0.16
	0.1	05/18/1999	1000	3.44	0.77	1.55	0.18	0.29	2.16	1.04	3.49	0.49	0.15
	0.1	06/14/1999	1000	0.63	6.4	10	<0.04	U	2.4	0.87	3.27	0.28	0.2
	0.1	07/13/1999	1015	0.89	4.61	4.22	0.28	0.07	2.37	0.4	2.84	0.23	0.18
	0.1	08/17/1999	1010	1.06	3	2.8	0.07	0.26	1.89	0.41	2.56	0.2	0.2
	0.1	09/13/1999	1030	1.18	2.03	2.82	0.06	U	1.69	0.4	2.09	0.26	0.2
Average				1.25	2.83	3.59	0.15	0.20	1.95	0.58	2.66	0.28	0.18
TC - 3	18	06/05/1996	0818	8.25	5.74	5.17	1.15	0.03	1.8	0.6	2.43	1.1	0.48
	13.5	07/19/1996	1114	2.26	3.47	4.24	0.12						
	16.5	08/13/1996	1102	2.17	3.08	4.04	0.16						
	16.5	09/16/1996	1047	2.43	2.5	3.28	0.19						
Average				3.78	3.70	4.18	0.41	0.03	1.80	0.60	2.43	1.10	0.48
TC - 3	15	04/23/1997	1125	0.3	0.34	0.49	<0.04	0.86	1.5	1.4	3.76	0.18	0.17
	15	05/21/1997	1240	0.74	0.4	0.54	0.09	0.13	1.4	0.4	1.93	0.35	0.18
	16	06/18/1997	1136	4.21	2.14	2.04	0.26	<0.02	1.33	0.6	1.93	0.22	0.17
	15	07/21/1997	1555	0.77	3.69	4.64	<0.04	<0.02	1.8	0.4	2.2	0.25	0.17
	15	08/21/1997	1025	1.7	3.28	3.32	0.13	0.13	1.59	0.8	2.52	0.59	0.21
	16	09/15/1997	1246	1.5	2.05	3.1	0.07	0.02	1.46	0.7	2.18	0.58	0.25
Average				1.54	1.98	2.36	0.14	0.29	1.51	0.72	2.42	0.36	0.19

Station	Depth M	Date mm/dd/yy	Time hh/mm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	Ammonia mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L
TC - 3	15	04/22/1998	1100	0.35	0.34	0.2	0.06	0.38	1.43	0.7	2.51	0.27	0.22
	13.5	05/12/1998	1104	0.36	0.31	0.27	<0.04	0.02	1.48	0.6	2.1	0.47	0.21
	14	06/09/1998	1024	3.03	1.1	1.78	0.34	<0.02	1.48	0.6	2.08	0.25	0.18
	16.5	07/16/1998	1037	2.09	4.02	3.75	2.81	0.12	1.36	0.6	2.08	0.37	0.16
	15	08/10/1998	1045	1.33	3.19	3.42	0.11	<0.02	1.55	0.4	1.95	0.38	0.24
	13	09/08/1998	1033	1.26	1.54	2.18	0.12	0.03	1.98	0.2	2.21	0.27	0.24
Average				1.40	1.75	1.93	0.69	0.14	1.55	0.52	2.16	0.34	0.21
TC - 3	15	04/12/1999	1135	0.24	0.16	0.11	<0.04	0.14	1.22	0.31	1.67	0.17	0.14
	18	05/18/1999	1018	3.29	0.67	2.02	0.18	0.33	2.17	0.92	3.42	0.47	0.15
	18	06/14/1999	1018	0.43	4.67	4.16	0.04	U	2.05	0.66	2.71	0.25	0.17
	20	07/13/1999	1035	0.97	4.53	4.56	0.18	0.1	2.38	0.39	2.87	0.25	0.18
	16	08/17/1999	1026	1.07	3.07	2.73	0.08	0.02	1.86	0.44	2.32	0.21	0.2
	16	09/13/1999	1046	1.11	2	2.71	0.05	U	1.73	0.39	2.12	0.26	0.21
Average				1.19	2.52	2.72	0.11	0.15	1.90	0.52	2.52	0.27	0.18
TC - 8	0.1	07/17/1996	0930	3.15	2.79	3.32	<0.1						
	0.1	08/13/1996	0915	2.19	3.13	3.82	0.15						
	0.1	09/16/1996	0915	2.23	2.46	3.42	0.17						
Average				2.52	2.79	3.52	0.16						
TC - 8	0.1	04/23/1997	1040	0.5	0.49	0.47	<0.4	0.4	1.55	1.4	3.35	0.19	0.14
	0.1	05/21/1997	1120	5.9	<0.1	0.7	<0.1	0.26	1.09	1.4	2.75	0.21	0.13
	0.1	06/18/1997	1050	14.25	3.73	4.2	0.53	0.21	1.08	1.2	2.49	0.15	0.11
	0.1	07/21/1997	1500	1.79	3.32	3.36	0.08	0.12	1.87	0.8	2.79	0.35	0.22
	0.1	08/21/1997	1145	2.03	2.45	3.27	0.09	0.21	1.55	2.2	3.96	0.29	0.21
	0.1	09/15/1997	1015	1.65	1.93	2.69	0.08	0.04	1.18	1	2.22	0.56	0.25
Average				4.35	2.38	2.45	0.20	0.21	1.39	1.33	2.93	0.29	0.18
TC - 8	0.1	04/22/1998	1000	0.42	0.34	0.19	<0.04	0.28	1.55	0.7	2.53	0.35	0.27
	0.1	05/12/1998	1020	0.44	0.3	0.27	<0.04	0.13	0.92	0.8	1.85	0.19	0.16
	0.1	06/09/1998	0930	10.1	3.89	4.02	0.65	<0.02	1.62	1.1	2.72	0.21	0.19
	0.1	07/16/1998	0945	2.51	4.15	4.25	2.85	0.12	1.51	0.7	2.33	0.29	0.21
	0.1	08/10/1998	1000	1.17	2.49	2.61	0.11	0.04	1.44	0.5	1.98	0.46	0.27
	0.1	09/08/1998	0940	1.23	1.13	1.6	0.12	0.03	2.27	1.1	3.4	0.59	0.23
Average				2.65	2.05	2.16	0.93	0.12	1.55	0.82	2.47	0.35	0.22
TC-8	0.1	04/12/1999	1053	0.91	0.27	0.47	0.06	0.32	1.46	0.8	2.58	0.25	0.18
	0.1	05/18/1999	0915	4.03	1.05	2.65	0.2	0.33	2.01	0.97	3.31	0.52	0.17
	0.1	06/14/1999	0935	0.59	4.7	4.92	<0.04	0.23	2.13	0.89	3.25	0.31	0.18
	0.1	07/13/1999	0935	0.94	4.59	4.51	0.23	0.07	2.26	0.45	2.78	0.27	0.2
	0.1	08/17/1999	0940	1.03	2.96	2.92	0.07	0.02	1.85	0.44	2.31	0.21	0.2
	0.1	09/13/1999	1000	1.14	1.47	2.4	0.06	U	1.61	0.5	2.11	0.26	0.22
Average				1.44	2.51	2.98	0.12	0.19	1.89	0.68	2.72	0.30	0.19

Station	Depth M	Date mm/dd/yy	Time hh/mm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	Ammonia mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L
TC - 8	12.5	07/17/1996	0943	3.08	2.64	3.95	0.15						
	12.5	08/13/1996	0928	2.41	3.17	3.89	0.19						
	13	09/16/1996	0928	2.21	2.1	3.18	0.17						
Average				2.57	2.64	3.67	0.17						
TC - 8	13	04/23/1997	1053	0.33	0.38	0.43	0.04	0.73	1.29	1.1	3.12	0.18	0.15
	12	05/21/1997	1132	2.78	1.4	1.83	0.32	0.14	1.11	1.2	2.45	0.2	0.13
	13	06/18/1997	1103	9.95	<0.05	3.17	0.35	<0.02	1.25	0.6	1.85	0.23	0.17
	12	07/21/1997	1512	2.14	4.02	3.7	0.11	0.07	1.94	0.8	2.81	0.29	0.27
	12	08/21/1997	1157	1.75	2.52	2.23	0.13	0.17	1.21	1.6	2.98	0.37	0.23
	12	09/15/1997	1027	1.57	1.89	2.44	0.08	0.05	1.17	0.8	2.02	0.41	0.27
Average				3.09	2.04	2.30	0.17	0.23	1.33	1.02	2.54	0.28	0.20
TC - 8	11	04/22/1998	1011	0.44	0.23	0.17	0.04	0.27	1.53	0.7	2.5	0.33	0.27
	11	05/12/1998	1031	0.35	0.24	0.23	0.05	0.13	0.96	0.8	1.89	0.17	0.16
	12	06/09/1998	0942	8.4	3.81	4.46	0.66	<0.02	1.9	0.7	2.6	0.32	0.21
	14.5	07/16/1998	1000	2.37	3.24	3.8	2.32	0.15	0.93	0.8	1.88	0.39	0.15
	12.5	08/10/1998	1013	1.23	2.4	1.86	0.12	0.02	1.31	0.5	1.83	0.5	0.24
	11.5	09/08/1998	0952	1.12	1.2	1.57	0.12	0.05	1.92	0.7	2.67	0.42	0.22
Average				2.32	1.85	2.02	0.55	0.12	1.43	0.70	2.23	0.36	0.21
TC - 8	11	04/12/1999	1104	0.46	0.24	0.2	0.04	0.26	1.25	0.56	2.07	0.22	0.18
	14	05/18/1999	0929	3.79	0.76	1.95	0.17	0.37	2.03	1.45	3.85	0.74	0.15
	13	06/14/1999	0948	0.88	5.4	9	0.08	U	2.15	0.7	2.85	0.31	0.21
	17	07/13/1999	0952	1	4.86	4.41	0.31	0.44	2.21	0.5	3.15	0.27	0.18
	12	08/17/1999	0952	1.13	1.82	1.9	0.08	U	1.86	0.52	2.38	0.23	0.21
	12	09/13/1999	1012	1.27	1.81	2.54	0.07	U	1.61	0.43	2.04	0.29	0.23
Average				1.42	2.48	3.33	0.13	0.36	1.85	0.69	2.72	0.34	0.19
TC - 11	0.1	06/05/1996	0900	8.02	5.18	6.13	1.14	<0.02	1.97	0.6	2.57	0.65	0.29
	0.1	07/17/1996	1000	1.69	3.59	4.38	0.09						
	0.1	08/13/1996	0945	3.5	1.6	4.4	<0.1						
	0.1	09/16/1996	0945	2.17	2.12	2.42	0.17						
Average				3.85	3.12	4.33	0.47		1.97	0.60	2.57	0.65	0.29
TC - 11	0.1	04/23/1997	0945	0.5	<0.1	<0.1	<0.1	0.49	1.31	1.6	3.4	0.22	0.16
	0.1	05/21/1997	1010	10.28	2.73	4.41	0.55	0.21	0.54	1.5	2.25	0.16	0.11
	0.1	06/18/1997	1020	19.75	6.04	4.76	0.9	0.4	1.69	1.2	3.29	0.34	0.2
	0.1	07/21/1997	1415	1.67	3.47	3.57	0.09	0.04	1.88	0.8	2.72	0.33	0.21
	0.1	08/21/1997	1305	1.92	3.43	2.67	0.15	0.07	1.53	0.9	2.5	0.28	0.21
	0.1	09/15/1997	0940	1.72	1.91	2.15	0.08	0.04	1.2	0.4	1.64	0.37	0.24
Average				5.97	3.52	3.51	0.35	0.21	1.36	1.07	2.63	0.28	0.19

Station	Depth M	Date mm/dd/yy	Time hh/mm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	Ammonia mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L
TC - 11	0.1	04/22/1998	0930	0.2	0.14	0.11	<0.04	0.08	1.84	0.4	2.32	0.31	0.3
	0.1	05/12/1998	0956	0.43	0.16	0.19	0.04	0.3	0.01	1.1	1.41	0.2	0.02
	0.1	06/09/1998	0900	15.2	5	9	0.73	<0.02	2.62	1.1	3.72	0.36	0.28
	0.1	07/16/1998	0930	2.93	3.63	3.17	2.54	0.03	1.3	1.1	2.43	0.33	0.21
	0.1	08/10/1998	0930	1.2	1.72	1.33	0.12	0.1	1.2	0.7	2	0.57	0.26
	0.1	09/08/1998	0910	1.18	1.08	1.38	0.1	0.07	2.27	1.1	3.44	0.41	0.24
Average				3.52	1.96	2.53	0.71	0.12	1.54	0.92	2.55	0.36	0.22
TC - 11	0.1	04/12/1999	0945	1.15	0.31	0.73	0.08	0.38	1.91	1.29	3.58	0.29	0.2
	0.1	05/18/1999	0950	10.5	1.79	3.76	0.3	0.22	2.1	1.05	3.37	0.53	0.15
	0.1	06/14/1999	0905	2.14	4.6	4.68	0.12	U	1.81	1	2.81	0.33	0.25
	0.1	07/13/1999	0910	1.08	3.68	2.91	0.27	0.08	1.97	0.83	2.88	0.18	0.22
	0.1	08/17/1999	0915	1.38	1.56	1.92	0.04	U	1.96	0.69	2.65	0.31	0.23
	0.1	09/13/1999	0930	0.89	1.1	1.5	0.05	0.63	1.35	1.03	3.01	0.38	0.26
Average				2.86	2.17	2.58	0.14	0.33	1.85	0.98	3.05	0.34	0.22
TC - 11	9	06/05/1996	0909	9.65	5.58	5.39	1.08	0.07	1.47	0.6	2.14	0.56	0.52
	3.5	07/17/1996	1004	1.84	3.51	4.16	0.1						
	3.5	08/13/1996	0949	2.42	1.32	2.72	0.14						
	4.5	09/16/1996	0950	1.87	1.39	1.84	0.16						
Average				3.95	2.95	3.53	0.37	0.07	1.47	0.60	2.14	0.56	0.52
TC - 11	5	04/23/1997	0950	0.43	0.37	0.44	<0.04	0.66	1.37	1.9	3.93	0.26	0.19
	4	05/21/1997	1014	10	3.8	3.67	0.47	0.21	0.54	1.6	2.35	0.29	0.11
	4	06/18/1997	1024	14.95	5.36	4.35	0.79	0.07	1.45	1.2	2.72	0.22	0.2
	4	07/21/1997	1419	1.86	3.62	4.39	0.1	<0.02	1.91	0.5	2.41	0.34	0.22
	4	08/21/1997	1309	1.58	2.23	2.28	0.1	0.13	1.19	1.9	3.22	0.5	0.23
	4	09/15/1997	0944	1.59	1.9	2.26	0.08	0.04	1.18	1.2	2.42	0.44	0.24
Average				5.07	2.88	2.90	0.31	0.22	1.27	1.38	2.84	0.34	0.20
TC - 11	4	04/22/1998	0934	0.26	0.13	0.25	<0.04	0.07	1.95	0.5	2.52	0.33	0.3
	3.5	05/12/1998	1000	0.35	0.16	0.15	0.05	0.25	0.01	1.2	1.46	0.19	0.02
	3.5	06/09/1998	0904	17.5	9.2	4.7	0.79	0.07	2.42	1.6	4.09	0.39	0.3
	5.5	07/16/1998	0936	2.93	3.62	3.63	2.53	0.16	1.63	0.6	2.39	0.51	0.21
	5	08/10/1998	0935	1.06	1.29	1.65	0.1	0.04	1.21	0.7	1.95	0.67	0.26
	4	09/08/1998	0914	1.21	1.51	1.04	0.11	0.08	1.06	0.7	1.84	0.38	0.26
Average				3.89	2.65	1.90	0.72	0.11	1.38	0.88	2.38	0.41	0.23
TC - 11	3.5	04/12/1999	0949	1.34	0.36	0.72	0.08	0.43	1.83	1.09	3.35	0.31	0.21
	5	05/18/1999	0955	12.5	2.3	4.11	0.21	0.22	1.96	1.07	3.25	0.56	0.14
	4.5	06/14/1999	0910	3.98	4	4.36	0.2	0.22	2.15	1.3	3.67	0.48	0.22
	8	07/13/1999	0918	1.16	4.19	3.69	0.27	0.18	2.09	0.55	2.82	0.31	0.23
	4	08/17/1999	0919	1.39	1.09	1.08	0.1	0.12	2.02	1.2	3.34	0.45	1
	4	09/13/1999	0934	0.88	1.13	1.55	0.06	0.04	1.36	0.97	2.37	0.39	0.27
Average				3.54	2.18	2.59	0.15	0.20	1.90	1.03	3.13	0.42	0.35